DOCUMENT RESUME

ED 463 977 SE 066 048

AUTHOR Cheng, May Hung
TITLE Becoming Confident Teachers of Science: Changes of Science Teaching Efficacy Beliefs.
PUB DATE 2002-00-00
NOTE 17p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (New Orleans, LA, April 1-5, 2002).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Constructivism (Learning); Elementary Education; Foreign Countries; Higher Education; *Preservice Teacher Education; *Preservice Teachers; *Science Education; Science Teachers

ABSTRACT

This paper describes the experience of a group of student-teachers in an initial teacher education program in Hong Kong. In preparing the student-teachers to teach science, the program introduced a module on science teaching that included a discussion of the various approaches to teach science and in particular, teaching science based on a constructivist view of learning was discussed. The teacher educator had implemented a number of strategies including: acknowledging the importance of the past experience of the student-teachers; "practice what they preach," and encouraging student-teachers to reflect. The influence of the module is reflected by the changes in the Science Teaching Efficacy Beliefs of the student-teachers at two phases: before they took the module on science teaching; after they took the module and after their teaching practice period. A comparison of the findings suggested that the student-teachers were more confident with teaching science, knowing more about how to engage pupils in activities and knowing that their effort would take effect. Based on the findings, the paper suggests a model adopting a socio-cultural view of learning to explain the learning of the student-teachers. (Contains 25 references.) (Author/MM)

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Becoming Confident Teachers of Science: Changes of Science Teaching Efficacy Beliefs

by

May Hung Cheng

M.H. Cheng

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Becoming confident teachers of science:
changes of Science Teaching Efficacy Beliefs

CHENG May Hung, May
The Hong Kong Institute of Education

Paper presented at the 2001 National Association for Research in Science Teaching Annual International Conference, New Orleans

Abstract

This paper describes the experience of a group of student-teachers in an initial teacher education programme in Hong Kong. In preparing the student-teachers to teach science, the programme introduced a module on science teaching that included a discussion of the various approaches to teach science and in particular, teaching science based on a constructivist view of learning was discussed. The teacher educator had implemented a number of strategies including: acknowledging the importance of the past experience of the student-teachers; "practice what they preach", and encouraging student-teachers to reflect. The influence of the module is reflected by the changes in the Science Teaching Efficacy Beliefs of the student-teachers at two phases: before they took the module on science teaching; after they took the module and after their teaching practice period. A comparison of the findings suggested that the student-teachers were more confident with teaching science, knowing more about how to engage pupils in activities and knowing that their effort would take effect. Based on the findings, the paper suggests a model adopting a socio-cultural view of learning to explain the learning of the student-teachers.

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Preparing teachers to teach with a constructivist view of learning

The present study is formulated based on a determination and concern to improve the quality of science teacher education. In Hong Kong, primary science learning is integrated in the General Studies Curriculum which also includes two other main areas of study social studies and health education. Most of the teachers who teach the General Studies subject or student-teachers who enroll in this subject area in the teacher education programme have an arts background in their secondary education (So, Cheng and Tsang, 1998). The confidence to teach science topics among these teachers or student-teachers were found to be low. The author was responsible for the delivery of a Curriculum Studies module in teaching science topics at the primary level. This study was conducted with an aim to improve the quality of science teacher education and hence improving the confidence to teach science topics among the student-teachers. In designing the module, relevant literature was consulted and a number of suggestions were considered. The strategies that may facilitate the development of student-teachers in teaching science with a constructivist view of learning were adopted. A number of strategies have been suggested in the literature to facilitate the development of the student-teachers to teach in a way that is based on a constructivist view of learning. They include:

i. acknowledging the importance of the past experience of the student-teachers;
ii. teacher educators should "practice what they preach";
iii. encouraging student-teachers to reflect; and
iv. developing student-teachers' confidence and self-efficacy in science teaching.

These strategies aim to generate changes in the teaching of the student-teachers such that they may teach science based on a constructivist view of learning. However, changes in teaching actions may occur when there are changes in views of learning and teaching, accompanied by gains in confidence in teaching science. These strategies therefore aim to generate changes in the student-teachers' views of learning and teaching, confidence in teaching science, and classroom practice.

Acknowledging the importance of the past experience of the student-teachers

From a sociocultural view of learning, the previous learning experience of the student-teachers may be interpreted as originating from a cultural background which may not be consistent with the culture in the teacher education programme. The personal conceptions of student-teachers that are held as they come to teacher education courses, can exert a powerful influence on what they learn and accept as valid knowledge (Kagan, 1992; Mahlios and Maxson, 1995). This gap in the teacher education programmes contributes to a failure or influence the student-teachers' ability to achieve meaningful learning and reflective inquiry (Calderhead, 1991; Gunstone and Northfield, 1992; Tobin,

1992). Feiman-Nemser (1989) recommended that teacher educators be aware of the incoming beliefs and attitudes or the preconceptions of the student-teachers in order to promote conceptual changes in pedagogical thinking.

In line with this call for considering preconceptions in teacher learning, Loughran (1997) maintained that student-teachers need to be challenged through pedagogy and be stimulated to consider and reconsider their existing knowledge in light of the new experiences. In this way, existing views of science teaching can be reconsidered as the student-teachers gain new science learning experiences. Therefore a part of teacher education is teacher educators eliciting student-teachers' preconceptions about science teaching, changing their views about teaching and learning, and facilitating changes in their practice in the classrooms. Carey (1985) shared this view that changes in teaching beliefs and practices are incremental. These studies suggest that teacher educators have to start from the student-teachers' previous views about science teaching and learning, and work to change these ideas to consider the implications of the constructivist view of learning for the classroom practice.

Teacher educators need to "practice what they preach"

The second strategy for helping student-teachers to teach science based on a constructivist view of learning involves the teacher educators putting into practice what they preach. A number of studies have been conducted to inform how science method courses in teacher education programmes may be conducted to promote teaching based on a constructivist view of learning (Abd-El-Khalick and BouJaoude, 1997; Stofflett and Stoddart, 1994; Munby and Russell, 1997; McDevett, Heikkinen, Alcorn, Ambrosio and Gardner, 1993). Findings from these studies suggest that as student-teachers are asked to teach with a constructivist view of learning, teacher educators should assume the same approach. Moreover, student-teachers must learn science concepts or science teaching with a constructivist view of learning before they are able to teach using the same approach (Stofflett and Stoddart, 1994). Consistent with this argument, McDevett, Heikkinen, Alcorn, Ambrosio and Gardner (1993) suggested that either science content or science method courses in teacher education programmes should build upon student-teachers' experiences, and emphasize science concept development and changing alternative concepts. By "practising what they preach", the teacher educator is modelling the teaching approach that is advocated to the student-teachers. The relationship between modelling and learning to teach science is illustrated by Russell (1997) and Loughran (1997). The process includes the communication of the approach by the teacher educator, and reflection among the student-teachers. By being engaged in the learning process themselves, the student-teachers have an authentic experience of seeing and feeling the diversity of outcomes for themselves through learning from a particular approach.

Encouraging student-teachers to reflect

The third strategy to prepare student-teachers to teach with a constructivist view of learning is to encourage student-teachers to engage in discussion, and stimulate their reflection. Loughran (1997) suggested that student-teachers reflect upon their cognitive and affective development after the teaching episodes in the teacher education programme. The student-teachers reflect on the pedagogy employed by the teacher educator, on how and why it was used as well as developed. The student-teachers then make their own decisions about how to adopt the approaches in their own practice. This process of reflecting on the learning experience was referred to as a "debriefing" by Meyer-Smith and Mitchell (1997). The debriefing included four dimensions: what science content was learnt, what was learnt about teaching, what was learnt about learning, and what was the impact (if any) on their personal beliefs about teaching and learning. Hoban (1997) suggested that the student-teachers analyse their own learning, identify enhancing and inhibiting factors, and hence distinguish the impact on their science teaching. Consistent with a constructivist view of learning, the above process involves learning to teach through experiencing learning, and hence leads to a construction of a personal pedagogy. The challenge for the teacher educator is thus to determine and bring into practice enjoyable learning experiences or effective teaching activities that are intended to be modelled, such that it becomes more likely that student-teachers will desire to include similar practices in their own science teaching. Moreover, reflection has to be promoted among the student-teachers such that they can build up their personal pedagogy.

Developing student-teachers' confidence and self-efficacy in science teaching

The fourth strategy for the teacher educator to help student-teachers to teach science based on a constructivist view of learning is to develop student-teachers' confidence and self-efficacy in science teaching. There are also studies that stress the development of teachers' attitudes and confidence in science teaching. Westerback and Long (1990) found that increased content knowledge could reduce experienced elementary teachers' anxiety about science teaching. They also reflected that teachers who are more comfortable with science are more likely to devote more time to teaching it, and are more likely to teach it with creativity. The notion of self-efficacy in science teaching is related to the attitudes and confidence in science teaching. Self-efficacy refers to the teacher's confidence and belief in being able to teach science and effecting learning outcomes among their pupils. The relationship between science teaching efficacy beliefs and preparing student-teachers to teach science is supported by a number of studies. Ramey-Gassert and Schroyer (1992) summarized related studies, linking quantitative findings with qualitative ones, and suggested that elementary teachers' poor self-efficacy has resulted in a science anxiety, poor attitudes towards science, and an unwillingness to spend time teaching science. Based on this notion, one of the aims for science teacher education courses should be to improve student-teachers' science teaching self-efficacy. Schamann and Orth Hampton (1995) believed that science teacher educators need to be aware of the implications, and organise method courses that improve student-teachers' science teaching self-efficacy. Moreover, Ramey-Gassert and

Schroyer (1992) suggested that purposeful selection of science experiences can improve science teaching self-efficacy and result in better attitudes towards science.

Science Teaching Efficacy Beliefs

Teaching Efficacy beliefs measures look into these two aspects: a personal belief about one's own ability to cope with a task (Self Efficacy) and a belief about action and outcome (Outcome Expectancy) (Bandura, 1977). Bandura (1977) hypothesized that an analysis of these two aspects would facilitate the prediction of behaviour. In the present study, this prediction may be applied to reflect how likely the student-teachers or beginning teachers will implement the science teaching strategies developed based on a constructivist view of learning. Teaching Efficacy Beliefs measures are more related to the conation aspect and tends to represent the sense of purpose or motivation of the teacher. This idea is related to the sociocultural view of learning which defines the mind as including three aspects namely, cognition, conation and affect. Although the notion of Teaching Efficacy Beliefs arise from a cognitive view, it is helpful in the sociocultural view of learning as it highlights the conation aspect.

The notion of Teaching Efficacy Beliefs has been further developed since Bandura first proposed it in 1977. Gibson and Dembo (1984) confirmed Bandura's two component model consisting of a) a factor that relates to a teacher's sense of teaching efficacy, or belief that a teacher's ability to bring about change is limited by factors external to the teacher (Outcome Expectancy) and b) a factor that relates to a teacher's sense of personal teaching efficacy, or belief that he or she has the skills to bring about student learning (Self Efficacy). In the present study, the meaning of self efficacy is adapted to reflect the student-teachers' or the beginning teachers' confidence or belief in being able to teach science and effect learning among their pupils. The self efficacy measurement is also taken as an indication of how likely the student-teachers and the beginning teachers will be to teach science with the strategies advocated in the present study, which means teaching science based on a constructivist view of learning.

As Bandura has defined self-efficacy as a general sense of teaching effectiveness, a teacher's overall level of self-efficacy may not accurately reflect their efficacy in teaching Science. Riggs and Enochs (1990) devised the Science Teaching Efficacy Beliefs Instrument, which is composed of two scales, the Personal Science Teaching Efficacy Belief Scale and the Science Teaching Outcome Expectancy Scale, to measure practising elementary school teachers' sense of science teaching efficacy. A similar instrument was also constructed for preservice teacher education students and was applied in predicting science teaching behaviours of student-teachers and in-service teachers (Enochs & Riggs, 1990).

In a study identifying the changes in preservice elementary teachers' sense of efficacy in teaching science, (Ginns, Watters, Tulip and Lucas, 1995), the results revealed that Science Teaching Efficacy and Science Teaching Outcome Expectancy were not significantly correlated, the former being more dependent on personal traits such as

internal locus of control and self concept, whereas the latter is related to levels of aspiration, academic interest and satisfaction. The study concludes that the Science Teaching Outcome Expectancy is more easily influenced by the teacher education programme than the Science Teaching Efficacy, as the latter is concerned more with global personality traits. It is, however, the concern of teacher educators to improve the students' sense of Science Teacher Efficacy, as this has implications for the teachers' ability to teach science and the children's ability to learn science (Riggs & Enochs, 1990). Finally, Ginns et.al. (1995) predicted that Science Teaching Efficacy is related to an individual's experience in learning science. For the present study, this means that the teacher education programme may influence the student-teachers' Science Teaching Outcome Expectancy beliefs and the student-teachers' experiences of science learning may be related to Science Teaching Efficacy.

Outcome expectancy and self efficacy beliefs can be applied to predict an individual's persistence of coping behaviour. As Gibson and Dembo (1984) predicted, the construct of teacher efficacy and outcome expectancy would reflect the degree to which teachers believed the environment could be controlled or the extent to which changes in students with given backgrounds can be made. They also suggested that teachers scoring high on both variables will cope with difficult situations with responsiveness, and teachers scoring low will give up readily if they do not get results.

Another direction of self-efficacy research has been to identify the factors that contribute to high science teaching self-efficacy beliefs. Ramey-Gassert, Shroyer and Staver (1996) obtained the personal science teaching self-efficacy and science teaching outcome expectancy scores of 23 elementary teachers. High science teaching outcome expectancy scores were found to be related to having personally experienced success in science and with teaching science. Among these teachers, the belief of students' success in science learning is found to be influenced by the teachers' success in their own science learning and teaching experiences. In another study, De Latt and Watters (1995) obtained the personal science teaching self-efficacy scores of 37 primary teachers and invited 5 teachers with high personal science teaching self-efficacy scores and 5 teachers with low personal science teaching self-efficacy scores to be interviewed. Relationships between individual attributes and science teaching self-efficacy were identified, for example, teachers with the highest personal science teaching self-efficacy scores expressed notions of confidence in teaching science, and felt that science was fun and interesting. These teachers were more oriented towards thematic and integrated approaches in science teaching. These data provide an association between the quantitative scores and the personality traits, the teaching and the confidence to teach among the primary teachers. In this way, positive changes in scores in personal science teaching self-efficacy and science teaching outcome expectancy can provide an indication of the positive changes in the confidence to teach science, as well as changes in science teaching practices. Moreover, providing positive science learning experiences for the teachers may also be one of the ways to obtain an increase in the personal science teaching self-efficacy and/or science teaching outcome expectancy scores. It is, therefore, of great concern among teacher educators to structure teacher education programmes that provide positive science learning experiences for the student-teachers

and to see an increase in the personal science teaching self-efficacy and science teaching outcome expectancy scores among them after the programme.

Method

In order to measure the changes in the confidence to teach science topics among the student-teachers, the Science Teaching Efficacy Beliefs instrument was adopted. There is a total of 25 item with a rating scale of 1 to 5, 1 meaning strongly disagree and 5 meaning strongly agree. The Science Teaching Efficacy Beliefs instrument (Riggs and Enochs, 1990) was adapted to reflect the local context, and was translated into Chinese. In order to identify if there were changes in the Science Teaching Efficacy Beliefs among the student-teachers in the teacher education programme, the instrument was administered at two points. The first time was before they took the Curriculum Studies module. This set the basis for comparison. The second time was after the teaching practice, just before they graduated in around June, which was the last month of the semester. The comparison showed the influence of the module and the teaching practice on their confidence to teach science.

The numbers of respondents in the quantitative part of the study at the different phases are summarized in Table 1. The questionnaires were sent out to all the student-teachers (N=39) in the first session of the Curriculum Studies module. The student-teachers were invited to fill in the questionnaires in the last session of the Curriculum Studies module. As three student-teachers were absent, a total of 36 questionnaires were collected. Another questionnaire was mailed to the student-teachers after the teaching practice, and a reminder was sent to those who did not return the questionnaires after one week. Finally, 27 returned the questionnaire. According to the returns after the teaching practice, 20 of the student-teachers taught science during their teaching practice. As science is taught in an integrated curriculum called General Studies at the primary level in Hong Kong, not all the student-teachers have an opportunity to teach science topics in their teaching practice.

Table 1 The number of respondents in the quantitative part of the study

Phase	**Number**
Before studying the Curriculum Studies module	39
After the teaching practice	27
Student-teachers who taught science during the teaching practice	20

Findings and Discussion

The Science Teaching Efficacy Beliefs (STEB) instrument (Appendix C2) measures the

Personal Science Teaching Efficacy Beliefs value and the Science Teaching Outcome Expectancy value. The alpha reliability values of the Science Teaching Efficacy Beliefs instrument was found to have a value of 0.59 and 0.78 before the commencement of the module and after the teaching practice respectively. Higher values in each or both of them indicates that the respondent is more confident in science teaching. From the Personal Science Teaching Efficacy Beliefs and the Science Teaching Outcome Expectancy values, the student-teachers were more confident in teaching science after the teaching practice. The student-teachers had significantly higher personal science teaching self-efficacy and outcome expectancy after the teaching practice (Table 2).

Table 2 A comparison of the Science Teaching Efficacy Beliefs value in the present study and those obtained in previous studies

	Before taking the module N= 39	**After the teaching practice N=20**	**De Laat and Watters (1995) Australia**	**Riggs and Enochs (1990) USA**
Personal Science Teaching Efficacy Beliefs	38.77 (5.18)	42.23 (7.06) **	49.6 (range 33-62) S.D. 5.9	56.54
Science Teaching Outcome Expectancy	34.26 (4.02)	39.19 (8.47) **	33.9 (range 20-44) S.D. 5.6	48.09

** $p<0.01$ Values in brackets are S.D.

This means that the student-teachers believed more strongly in their own competence to teaching science and in effectively positive learning outcomes in their pupils after the teaching practice. Compared with the mean values from other studies of primary student-teachers in Australia (de Laat and Watters, 1995) and the USA (Riggs and Enochs, 1990), the mean values for Personal Science Teaching Efficacy Beliefs is still lower, but that for Science Teaching Outcome Expectancy is higher than the Australian study. Although the values were still lower, the increase was significant and comparable with that of the Australian study.

A paired sample t-test was conducted to compare the response in the Science Teaching Efficacy Beliefs instrument. Out of the 25 items in the Science Teaching Efficacy Beliefs instrument, 8 items showed a significant difference among the respondents before studying the module and after the teaching practice (Table 3). These items showed that the respondents had more confidence with teaching science, knowing more about how to engage pupils in activities, knowing that their effort would take effect, and having comparable confidence in teaching science as in other topics. Their lack of knowledge about science concepts also contributes to the low confidence level before taking the module, as reflected by the mean values of items 8 and 12. However, after the teaching practice, this worry about content was lowered. The student-teachers had a more positive belief that their teaching was responsible for pupils' achievement and found themselves being able to help pupils experiencing difficulties after the teaching practice.

Table 3 Items in the STEB instrument that shows a significant difference before studying the module and after the teaching practice

Items in the STEB	**Mean before taking the module (N=39)**	**S.D.**	**Mean after the teaching practice (N=20)**	**S.D.**	**F value**
3. Even when I try very hard, I do not teach science-related topics as well as I do most topics. #	2.65	0.69	3.50	0.81	4.67***
5. I know the steps necessary to teach science-related concepts effectively.	2.85	0.16	3.31	0.68	2.48*
8. I generally teach science-related topics ineffectively. #	3.12	0.82	3.77	0.65	5.30***
12. I understand science concepts well enough to be effective in teaching science topics at the primary level. #	2.50	0.81	3.00	0.80	2.31*
14. The teacher is generally responsible for the achievement of students.	3.35	0.75	3.65	0.80	2.54*
21. Given choice, I would not invite the principal to evaluate my science teaching. #	2.84	1.07	3.36	0.91	2.59*
22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better. #	3.04	0.98	3.48	0.77	2.29*
24. I do not know what to do to get students engaged with science. #	3.00	0.82	3.64	0.70	2.87***

* p<0.05 ** p<0.01 *** p<0.005

Comparing the Personal Science Teaching Efficacy Beliefs values obtained before the module and after the teaching practice (Figure 1), the difference in the values among individual cases ranges from a gain of 17 to a decrease of 19 points. The difference in values for the Science Teaching Outcome Expectancy among individual student-teachers ranges from a gain of 14 to a decrease of 14 points (Figure 2). The range for the difference in the Personal Science Teaching Efficacy Beliefs values is 4 points wider than that for Science Teaching Outcome Expectancy (comparing Figure 1 and 2). Hence, though the trend for the whole group is an increase in confidence level, there were two

Negatively worded items have been recoded such that a higher mean value indicates higher science teaching efficacy beliefs.

individual student-teachers who had particularly negative changes in Personal Science Teaching Efficacy Beliefs values and one of them also had negative changes in the Science Teaching Outcome Expectancy value. As the questionnaire was anonymous, the author could not identify the individual who experienced such negative changes. The explanation was made based on a postulation that the student-teacher may have had much difficulty in teaching science during the teaching practice. On the whole, the student-teachers experienced a significant increase in their confidence to teach science, and the amount of change depends on individual situations which may include, their perception of learning in the Curriculum Studies module, and their experience in the teaching practice.

Figure 1 Difference in Personal Science Teaching Efficacy Beliefs values before and after the teaching practice

Figure 2 Difference in Science Teaching Outcome Expectancy values before and after the teaching practice

Conclusions and Implications

The findings of the study suggested that the student-teachers experience positive gains in their confidence to teach science. In order to explain this change, the student-teachers and the beginning teachers were regarded as learners in a process of learning to teach. Teacher development is explained as a sociocultural activity. This provides a lens to understand how the intervention conducted by the author may facilitate the gain in confidence to teach science and why the change may not be as significant in some individuals.

The student-teachers and the beginning teachers may be considered as novices being socialized into a new culture of science teaching. As a sociocultural activity, teacher development is a situated and contextualised activity. It is shaped by the context, which includes the settings of the teacher education institute, the classroom and the school. Moreover, the actions of the teacher educator in facilitating the development of the novices are purposeful activities that aim to help them to socialize to a culture of teaching science based on a constructivist view of learning.

First of all, facilitating the development of the novice is a situated and purposeful activity. The teacher educator can be regarded as an agent who made use of both mediated actions and mediational means in the process. In the present study, the purpose of the teacher educator was to help the student-teachers to teach science based on a constructivist view of learning. The mediated actions included the teaching and learning activities during the delivery of the Curriculum Studies module

From a sociocultural view of learning, teacher development is seen as a contextualised activity. The context of the teacher education institute or the beliefs of the teacher educator shaped the purpose or the intentions of the teacher educator. Thus, the interventions and effort to support teacher development are contextualised in a culture that values teaching science based on a constructivist view of learning. For the student-teachers in the teacher education programme, other cultural or contextual influences were acting on them, such as how other teachers taught in their past educational experiences, and how other lecturers taught in the science academic studies module in the programme. It may be interpreted that these influences the degree of change in the confidence to teach science.

In explaining teacher development as a sociocultural activity, interactions with the researcher and with peers are important during the Curriculum Studies module and the teaching practice. These interactions shape the thinking of the individuals and socialize them into the new culture of teaching science. The reflections and sharing in the Curriculum Studies module may help the student-teachers to change their conceptions about science learning and teaching. The interactions with teachers and pupils in the school may also influence their confidence and practice. The degree of influence during the teaching practice, in turn depends on the student-teachers' past educational experience in the secondary school and the teacher education programme.

Teacher educator may consider a number of implications drawing from this study. The content and pedagogy modules in the teacher education programme need to be introduced

with a similar approach or from strategies stemming from similar institutional cultures. Helping student-teachers to teach is viewed as a process of socializing the student-teachers into a new culture of teaching. Moreover, the lecturers need to give more consideration to the past learning experiences of the student-teachers. By acknowledging the past experiences of the student-teachers, the teacher educator may be able to design adequate learning experiences that suit the needs of the student-teachers and be aware of how they may interpret the meaning of the experiences.

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Signature: May Cheng	Printed Name/Position/Title: CHENG May Hung / Senior Lecturer/IOE
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